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AMERICAN JOURNAL OF OPTOMETRY

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AMERICAN JOURNAL OF OPTOMETRY

VOL. 12 JANUARY, 1935 No. 1

VISUAL EQUILIBRIUM*

A. E. Turville, Fellow of the British Optical Association
Northampton, England

The balancing of monocular functions so as to transform them into a complete state of perfect binocular activity is an important part of the work of the optometrist. Indeed it may be said that unless the monocular functions are co-ordinated to produce a perfect binocular action the work of the optometrist has remained incomplete or may even have failed completely in certain cases.

The above refers to cases in which there is binocular activity, or freedom from squint, amblyopia or diseased conditions. All the following remarks refer similarly.

It is, I believe, by a careful study of anomalies of "balance" in cases possessing binocular vision that we shall ultimately understand better the causes, many of which remain obscure, of the many squinting conditions we see. It may even be found, if it is indeed not already suspected by some of us, that squints may be caused, or at least precipitated, by quite small errors of refraction when those errors are different in amount as between the two eyes. Recent investigation, which I am about to discuss, definitely emphasizes not so much the harmful effect of small errors, which are already well known, but the extraordinarily harmful effect of small *differences* existing between the two eyes in certain types of cases.

A. J. Esdaile, whom we have so recently lost and mourned, and myself had for some time, in collaboration, discussed and experimented somewhat extensively in an effort to track down the cause or causes of many anomalies of imbalance associated with the more difficult type of asthenope. We felt there was something lacking in our conceptions of balance. So many things were not capable of explanation.

My own investigations into the relationship of Refraction to Migraine[1] convinced me that we were tending to overlook several important points in ocular activity. Our conception of "balance" was lacking in certain essentials. There were certain reactions without a traceable

*Submitted for publication Sept. 15, 1934.

[1] "Refraction & Migraine," A. E. Turville, "British Journal of Physiological Optics," Vol. VIII, No. 1, pp. 62 to 89.

cause. The very fact that the inclusion of base-in prisms in the prescription given to migraine sufferers, and that their inclusion invariably gave relief, only made confusion greater from the point of view of understanding the cause, because the effect was the same in all cases no matter what the lateral balances were. The prisms were affecting something through the extrinsic muscles but what that something was remained, for a considerable time, obscure.

Further study, carried out on every type of case possessing binocular functions, has enabled me to show with reasonable degrees of certainty, that the cause of very many of the signs and symptoms not always curable in the ordinary course of clinical work are definitely refractive in origin, that their immediate secondary effect is a form of ciliary imbalance, often complicated in nature, and that the associated extrinsic muscular imbalances are definitely secondary to the ciliary error. The final effect is one or all of the well known symptoms of eyestrain. And all this can, and does, persist in many cases, in spite of the most careful correction of refractive errors carried out in the usual manner.

The extrinsic conditions associated with the anomaly we are discussing must classed as "accommodative" and differentiated from such as would be classed as "physiological" or "pathological."

The worst form of 'ciliary imbalance" is that caused by a monocular latent difference of refractive error. Manifest differences are, in any case, easily found and corrected.

Unequal latency of small amount is definitely more troublesome to the patient than is a greater amount of equal latency.

Correcting manifest errors frequently leaves a small unequal latency unaccounted for. An estimation of the percentage of all cases possessing an unequal latency after a conventional refraction test is about 20%.

Unequal latent hyperopia frequently causes moderate amounts of hyperphoria. The test is best made at reading distance upon such a card as the Kratometer Card No. 4, using nothing but the correction found and a septum. If the hyperphoria disappears, or reduces, when a +0.5 sph. is placed over one eye or the other than the case is "accommodative" and possesses an unequal latency. The eye taking the sphere indicates the position of greatest latency. There may be unequal latent hyperopia without hyperphoria. Small amounts of latent myopia will give the same effect and are not uncommon.

Cyclophoria may be accommodative, often is in fact. Here there is an attempt to auto-correct astigmatism. This frequently results in sectional ciliary activity, lens tilt and the establishment of a secondary lenticular astigmatism. There is a sectional reflex action resulting in erroneous stimulation of the obliques and a resulting cyclophoria. Cyclophoria can be eliminated in many cases of even very low astigmatism by varying the cyl. strength and axis. The same card and apparatus as suggested for use in detecting hyperphoria will show cyclophoria. Auto-

corrected astigmatism may be locked in, as may hyperopia, and thus it becomes correct to discuss it as latent astigmatism and again it may be, often is, unequal in its latency.

Cases possessing an unequal latency may have, usually do have, monocular and binocular normal visual acuity both at distance and near when wearing a conventional correction.

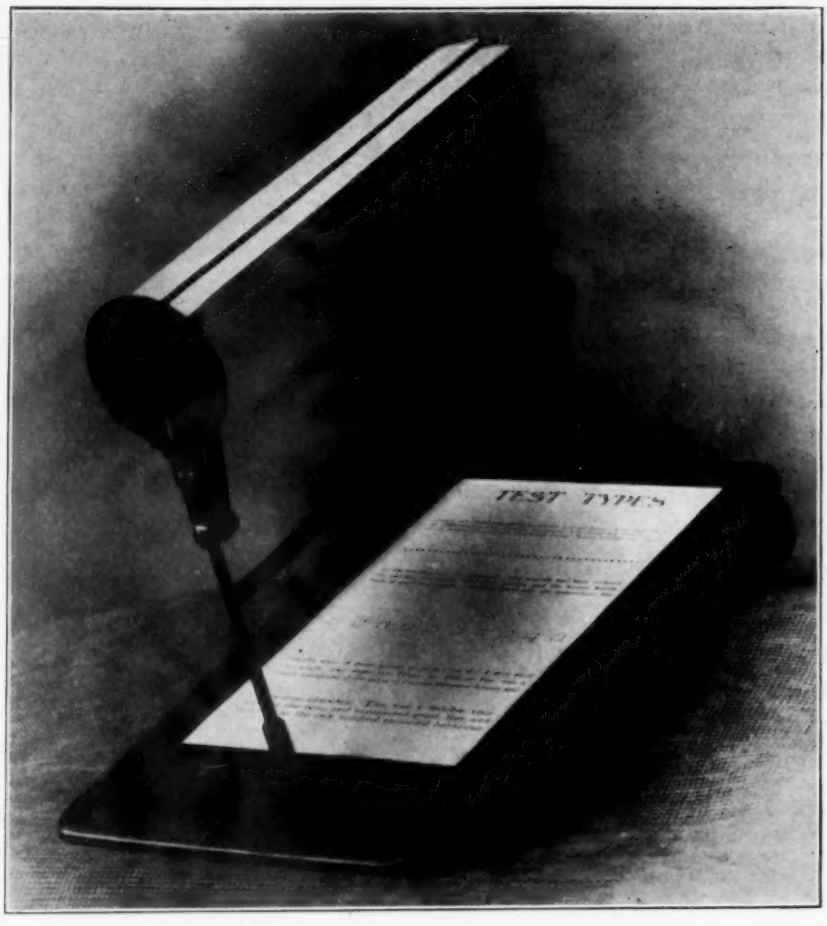
Dynamic retinoscopy will permit of the detection of latent differences in some cases but is a method which will not always indicate the correction to give. It needs support from a subjective method.

The Lockwood Cross Cylinder Test will disclose the presence of unequal latencies but the method is cumbersome and not always to be relied upon in estimating the finer shades of error. Perhaps the greatest argument against the test is that it creates artificial conditions of extrinsic activity which react against the possibility of estimating the true state of habitual ciliary activity.

Various methods of simultaneous monocular testing, at near point, such as might be made upon two similar objects in the Kratometer or Synoptophore or Comparator have been tried but only with partial success. The fault in such methods lies in the fact that the patient cannot observe two objects at once for comparative purposes. There must be a definite "switch" from one object to the other, introducing a time factor which permits an adjustment of the ciliary muscle while changing observation. Such adjustment nullifies the test.

Such arguments as have so far been outlined, based upon investigations made, resulted in the postulation of a demand for an apparent impossibility. The need was for "an opportunity of examining each eye separately (subjectively) at reading distance" with each eye observing the same object simultaneously"![2] Reference to Fig. 1 will show the simple apparatus known as the Esdaile-Turville Equilibrium Test, which has been devised as an effective means of testing each eye separately without conscious knowledge on the part of the patient that more than one object is being observed. There is definitely no "switch" or adjustment of the ciliary muscle with transference of observation; the patient subconsciously appreciating only a single object. In effect the reading chart *is* a single object, the print, etc., on it being part of the whole. The septum, suitably arranged in distance and adjustable in width occludes part of the right half of the chart from the left eye and *vice versa*. The two occluded parts, if the adjustments are correctly made and the distance of chart from the eyes is correctly set, meet exactly, and the patient appreciates the card as it would be seen were the septum not in place—except that if there is a difference in visual activity or refraction or latency as between the two eyes the type on one side will appear less clear or there may be an appreciable size-difference. The apparatus will, simultaneously

[2] "The Common Complaint," A. E. Turville, "Dioptric Review," Vol. XXXVI, No. 4, pp. 199-205. August, 1934.



Esdaile-Turville Equilibrium Test
Fig. 1

with the clearness and size test, show hyperphoria and cyclophoria. One is able to notice the effect of lens alterations upon vertical 'phorias and cyclophorias at the same time as upon visual clearness and size.

To obtain the finest possible shades of difference the illumination on the chart should be low, in fact the patient should barely read the type set at the top of the chart, Fig. 2, which is J2 in size. Tests on type should then be made using the second lot from the top which is J3 in size. The dotted line is for hyperphoria and cyclophoria testing. The row of squares is for an estimation of equality or difference in image size. The lower sets of type are useful for use with older people or others possessing reduced visual acuity especially when the light is reduced. The light may conveniently be obtained from a shaded lamp which shines on

to the wall or ceiling behind or above the patient. The light needs controlling by means of a rheostat, different people possessing quite different thresholds.

The disc, upon which are engraved two scales, seen in Fig. 1, turns, and with it turns a cam which permits widening or reducing of a spring-held two-bladed septum.

The two scales are, First: P.D. of patients, 54 to 70 mm, the chart to be held at 40 cms. from the eyes. Forty centimetres is the distance recommended for making the test. The other scale is similarly engraved in P.D. but for 33 cms. distance of chart from the eyes.

Fig. 3 shows the Equilibrium Test apparatus held in position by the patient. Both hands should be used and the chart held in the ordinary reading position. Once the chart is set in position by the optometrist, who can immediately see whether it is correctly held or not, there is no difficulty in the patient maintaining the position throughout. The patient needs impressing with the necessity for concentrating upon the print.

With the distance correction (plus presbyopic addition if any) in place, the patient holding the chart and with the light suitably lowered, the patient is required to say (1) whether the dotted line is straight, (2) whether the print on the right and the left sides is equally clear and (3) whether the squares are equal in size on each side.

Size and clearness often equalize simultaneously when monocular adjustments to the lenses are made. Hyperphoria, if any, may also be reduced or will disappear with the same adjustment.

A weak plus sphere is first to be added to the correction over the blurred eye. A +0.25 sphere is enough to start with. In a surprising number of cases this first move completely clears a noticeable blur on one side and produces equality with the print on the other side. Increase the added sphere if necessary. If several increases give no result remove the addition and try a minus 0.25 sphere over the other eye.

The added plus, when effective, probably only represents part of the monocular latency in some cases in which case more will be evident in a later test made in several months' time. In practice it has been found undesirable to give more than equalizes the clearness of vision at the time of testing.

When more plus must be added to one eye at the near test than will be tolerated in the distance without noticeable *binocular* blur consideration must be given to a temporary reduction for constant use or separate reading glasses must be prescribed.

When monocular spherical adjustment fails to provide the required equality, or visual balance, the cylinders need investigating. First check the axis over the blurred eye by rotating the cylinder. If the cylinder is a weak one double its strength just for this check and revert when the axis is definitely found. Next check the strength using a Jackson cross cylinder. Often an alteration, up or down, of 0.25 sph. will equalize

TEST TYPES

Showers of hot ashes rose into the air and fell on distant places; flying sparks carried the conflagration to great distances, and kindled it in twenty new spots at a time; church steeples fell down with tremendous crashes; houses crumbled into cinders

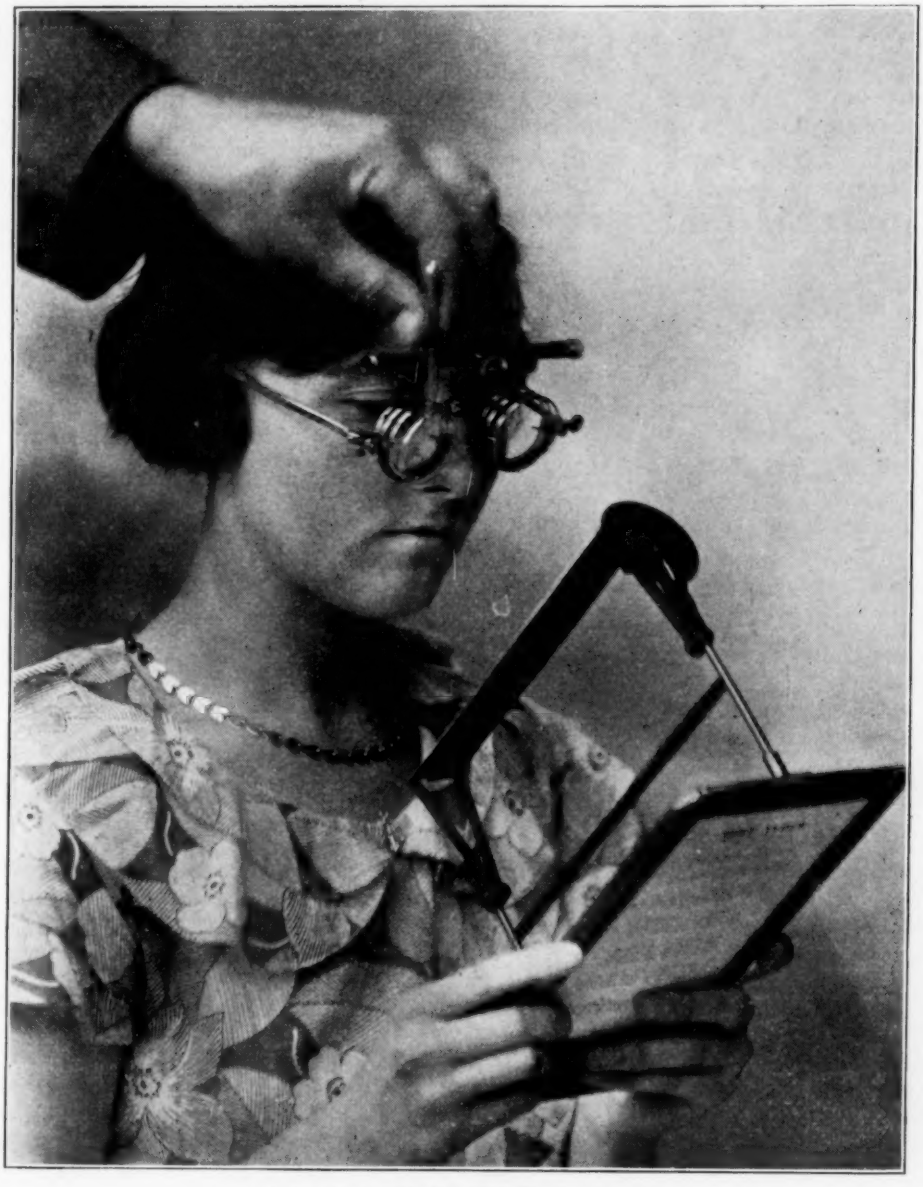
by the hundred and the thousand. The summer had been intensely hot and dry, the streets were very narrow, and the houses mostly built of wood and plaster. Nothing could stop the tremendous fire

but the want of more houses to burn; nor did it stop until the whole way from the Tower to Temple Bar was a desert, composed of the ashes of thirteen thousand houses and

eighty-nine churches. This was a terrible visitation at the time, and occasioned great loss and suffering to the two hundred thousand burnt-out

ESDAILE-TURVILLE EQUILIBRIUM TEST. COPYRIGHT

Fig. 2



Esdaile-Turville Equilibrium Test
Fig. 3

although, naturally, more will be needed in other cases. Cylinders, under this test, often need increasing. The cylinder over the other eye should be similarly checked. Having altered the cylinders return to distant charts

and check the spheres for best vision *monocularly* and return to the Equilibrium Test for a final spherical balancing.

It has been found in many cases that 5° alterations of axis, or perhaps more sometimes, with an alteration of strength of cylinder of only 0.25, in a case of even very low astigmatism, will eliminate unequal visual acuity and a marked amount of cyclophoria. Simultaneous alteration of the sphere value has also been known to remove hyperphoria in the same case.

Experience with the test has shown that minor adjustments of conventionally found corrections are extremely important in providing the visual comfort so long sought by many asthenopes and that in many cases, also, a careful balancing of the visual acuity under dynamic conditions makes unnecessary further consideration of extrinsic anomalies. The test, it is felt, provides a means of balancing at the original seat of stimulation of visual activity which, after all, is in the retina; ciliary and extrinsic muscular activities often being definitely secondary.

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HETEROPHORIA IN COLLEGE STUDENTS*

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In conjunction with a series of reading studies which are being made in the Psychological Laboratory at the University of Southern California the near point phorias (at 13 inches) of 191 unselected college freshmen were measured in order to select certain cases of high exophoria for special study by the use of eye movement photography. The results of this test appeared to be of interest to those in clinical practice.

The phoria was measured by the use of 2 three diopter vertical displacing prisms. These prisms were placed in a holder which was held by the tested. The test object was the common arrow above a line of letters and numbers, and the tested merely reported the number or letter to which the arrow pointed. If the student wore lenses, his phoria was measured with lenses. Although this method was probably not as accurate as the usual routine technique, it was found to be quite reliable with those students who were tested a second time.

The following table summarizes the results obtained. Plus indicates esophoria; minus indicates exophoria.

Phoria	+6	+2	+1	—0	—1	—2	—3	—4	—5	—6
No. of Cases	1	2	2	14	69	47	5	9	2	8

Phoria	—7	—8	—9	—10	—11	—12	—13	—14	—16	—18
No. of Cases	4	5	1	2	3	9	2	3	2	1

N=191

It will be noted from these data that 130 or 68.06% of the cases showed a phoria between "orthophoria" and 2 diopters of exophoria while only 19 or 9.94% of the cases exhibited a phoria ranging between 4 and 6 diopters which is taken as the usual standard. It is also of some

*Submitted for publication Dec. 3, 1934.

interest that the one case of 6 diopters of esophoria was wearing high minus lenses.

Assuming that these data are representative, which is probable with such a large group, and assuming that the test is valid, it would appear that two conclusions may be drawn:

1. That approximately 90% of the young men and women in college have improper binocular balance, or

2. New norms or standards should be considered for this age level.

The latter appears to be by far the most probable. It is not the purpose of this note to enter into an extensive discussion of this question but merely to present these data which tend to refute some norms of long standing, and which raise a definite problem. One aspect of this problem is being attacked in this laboratory in determining the effect of high exophoria on the reading act with the idea in mind to determine its importance in remedial reading in college students.

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ASTIGMATISM-TORSIONS AND THEIR EFFECT ON EACH OTHER*

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The objectives of this talk are: First, to persuade the audience that the ophthalmometer, as efficient as it is, can only occupy a secondary role in routine refraction, in fact, should only be used as an auxiliary and in the manner of an auxiliary. Second, that defects of the oblique muscles have been entirely neglected in the etiology of squints, phorias and ocular complaints; that oblique astigmatism is generally the cause of malfunctioning of the obliques, and that a correct understanding of the relation of one to the other is necessary for the proper handling of that type of case.

The ophthalmometer is generally conceded to be essential in a routine examination, but if the findings are not to be relied upon, is it not inferior to retinoscopy as a routine test? Leaving aside the matter of interpretation for a moment, if there exists a discrepancy between the ophthalmometer and the retinoscope I am inclined to believe that every refractionist of average skill with the retinoscope will rely on the latter to determine the astigmatism.

The deductions needed to arrive at the true total astigmatism are rather complicated and it is not at all sure that they are reliable.

The ophthalmometer should be used as an auxiliary:

1. To determine the corneal astigmatism as a point of information of very limited use in the final correction.

2. To detect irregular astigmatism, when suspected, as in low visual acuity uncorrected by lenses.

3. It is indispensable in the correction of keratoconus by contact lenses.

4. In aphakia and anisometropia.

Most necessary in a routine is a dependable method of retinoscopy. We determine with the retinoscope, the manifest error, the latent error, the amplitude of accommodation, the presbyopic addition and the

*An abridgement of the material presented before the Minnesota Academy of Optometry at the University of Minnesota, September 18, 1934.

astigmatism, if any. From the standpoint of lens to be prescribed, no other method compares with the retinoscope.

Opacities of the media are revealed at a glance. In fact, every other method and instrument could be discarded in refraction, yet leave fair accuracy, whereas eliminate the retinoscope and the result is a very doubtful correction.

In most routine refractions the ophthalmometer precedes the retinoscope. Why should it not follow the latter? And then only in cases of astigmatism as revealed by the retinoscope. If the refractionist wishes to accumulate data on corneal curvatures, it would of course be routine, otherwise it should be used only when indicated. The reason for this unorthodox statement is that astigmatism of moderate amounts, particularly with oblique axis, cannot be prescribed accurately by empirical deductions from ophthalmometer findings. To deduce the total astigmatism from the corneal astigmatism, it is necessary to do the following:

1. Allow for physiological astigmatism.
2. Allow for the difference in effectivity of the correcting lens when placed 15 mm. from the cornea instead of in the corneal plane.
3. Allow for the spherical element in combination with that cylinder.
4. In oblique axii, consider the change of axis and power due to the physiological astigmatism being against the rule. That is: two cross cylinders with their principle meridians less than 90° apart.
5. Allow for the fact that our findings are monocular and not associated as in binocular vision.
6. Consider the possibility of compensating astigmatism on the posterior surface of the cornea or of the lens.
7. Allow for the size and shape of the ocular image, in cases of anisometropia.

Advocates of the ophthalmometer ignore all these points or nearly all and offer as a substitute the Javal rule.

The Javal Rule

Neumueller in the October, 1933, issue of the American Journal of Optometry denies ever finding such a rule in Javal's original writings. On the other hand, Ryer and Hotaling in the February, 1930, issue of the same journal, defending the minus cylinder (somebody should champion the plus cylinder for the sake of fairness), apparently quotes Javal from the original: "Memoires d'Ophthalmometrie" published in 1891, and the formula is there given as:

$$\text{Ast.} = K + p \times \text{Asc.}$$

Where Ast. = Subjective Astigmia.
K = .50 cylinder against the rule.
p = 1.25.
Asc. = Corneal finding.

All Cylinders to be minus values, resultant spheres to be ignored.

It may be that the person translating this particular subject for Ryer and Hotaling were not thoroughly familiar with the terms, or it may have been merely a suggestion, put to practical application and made "Law" by custom.

Physiologic Astigmatism

1. Physiological astigmatism is set by most ophthalmometer addicts and by the so-called Javal rule at .50 with the rule. One supposition is that this is to allow for angle alpha, the angle formed by the optic axis and the line of fixation. This is not a fixed quantity as while the mean value may be 5°, it varies between 2° and 8°, being greater in hyperopes than in myopes. Physiologic astigmatism should be defined as that astigmatism most commonly found in the greatest number of individuals without complaint. The average of this astigmatism was found by Steiger to be about .70 of a diopter by examining the eyes of 3,170 pupils under 20 years of age and suffering from no complaints. This astigmatism correctible by a +.70 x 90 or —.70 x 180 was therefore called with the rule.

The definition is given by Gullstrand as: When the section of least curvature of the cornea makes an angle no greater than 30° with the horizontal, the astigmatism is with the rule, and we may add, correctible by a minus cylinder x 180° or a plus cylinder x 90° or within 30° of these.

In 86% of cases examined this quantity of astigmatism was found with the meridian of least curvature near the 180th meridian. However, physiological astigmatism as above defined may not be at 180°, but may have its least curvature in the 170° or 10°, thus complicating the subject still further.

Another theory is that physiologic astigmatism varies with age. This variation is given by Sheard as being .25 under 30 years of age, .50 between 30 and 60, and .75 over 60 years of age, all with the rule.

Still another theory is that physiologic astigmatism is due to pressure of the upper and lower lids against the globe causing an increase of curvature in the vertical meridian. The variation is thought to be due to increased rigidity of the eyeball with age and the relaxation of the lids caused by the stretching of the muscles and loss of tissue. Some of this with the rule astigmatism appears to be compensated by an against the rule astigmatism of the inside surface of the cornea, so that upon relief of the lid pressure in age, the vertical curvature flattens, the inside curvature dominates and the net physiological astigmatism changes from with the rule to against the rule. This theory of Gullstrand has a certain logical appeal, and if true would deny the usual deductions as proposed by Sheard, the Javal rule and others.

There is ample clinical evidence that astigmatism against the rule is more common in age than in youth.

If we admit this as a fact, our deductions for physiologic astigmatism should not be increased from .25 to .75 diopter as advocated by Sheard, but should start at the average of .70 as found by Steiger, decrease to zero and increase progressively against the rule in old age.

When these deductions are made, however, we have no assurance that said correction will be accepted as perfect. While angle alpha is responsible for some astigmatism, the eye being a compound optical system, with the line of fixation differing from the optic axis by a variable amount it is impractical to set a fixed deduction for that defect yet to be proven. Better to ignore physiological astigmatism altogether than to make an usually erroneous deduction.

Effectivity

2. The allowance for effectivity is necessary and is based on correct conclusions. A plus lens is stronger 15 mm. away than in the corneal plane, and conversely a minus lens is weaker. As the measurement is made in the corneal plane, the correcting lens will have to be increased, if minus, when placed 15 mm. away from the cornea and decreased if plus.

The Javal rule calls for an increase of 25% (x 1.25) in the correcting minus cylinder.

This part of the rule is grossly inaccurate in the lower powers. It becomes true only at about —16.00 diopters.

Spherical Component

3. When combined with hyperopia of a degree equal to or greater than the astigmatism, the case is one of compound hyperopic astigmatism and the final correction calls for a plus on plus. The effectivity of the lens is decreased and in a ratio different than if the lens were minus.

Neumueller explains this clearly in an article in the April, 1930, issue of the American Journal of Optometry.

Let us suppose that the ophthalmometer reading in a given case is: 42 diopters in 180°. 46 diopters in 90°. Resultant Astigmatism: 4.00 with rule.

Now the formula for lens effectivity may be expressed as:

$$\frac{1{,}000}{F - d}$$

F = being the power.

d = the distance from the plane of reference. Both in millimimeters.

The lens required 15 mm. from the cornea to correct 4.00 of corneal astigmatism would be:

$$\frac{1{,}000}{-250\text{-}15} = \frac{1{,}000}{-235} = -4.25$$

A minus lens being decreased in power when moved away from the cornea, a stronger lens is therefore needed in the 15 mm. plane.

If the lens were plus we could write it as $\frac{1{,}000}{-250\text{-}15} = 3.77$

as a plus lens is increased when moved away from the cornea and therefore a weaker lens in the 15mm. plane will satisfy the requirements of the corneal plane.

But disregarding physiologic astigmatism for simplicity, if we should apply the Javal rule for this case we would get:

$$D = -4\ -4/4 = -5$$

This is obviously .75 diopter too strong for effectivity.

Neumueller ignores this discrepancy, and brings out another:

Suppose that this case requires a +6.00 lens superimposed to the astigmatic correction to correct his hyperopia. We now have +2.00 ⌒ +4.00 x 90°△ and applying the Javal rule D = 4—4/4 = 3.00d. As we said above the actual lens needed is +3.77.

In the first case, we have myopic astigmatism requiring a —5.00 Cyl. for correction and in the second case, we have hyperopic astigmatism requiring a +3.00 for correction, both having the same corneal curvatures. The discrepancy is untenable.

Neumueller next states that the total stigmatism in proportions to the corneal varies with the amount of axial error.

His method is to refer the spherical ametropia back to the plane of the cornea, add the cylinder power at the cornea, and refer back to the lens the meridian of greatest refraction. The difference between the major and minor meridians in the plane of the lens gives us the true total astigmatism as deduced from the ophthalmometer findings. We therefore have an infinite variation in the amount of the cylinder deducted from the ophthalmometer findings, proportional to the myopia and inversely proportional to the hyperopia as shown by the retinoscope. Therefore as an auxiliary the ophthalmometer is entirely dependent on the retinoscope.

He gives the following illustration:

Let us assume that by retinoscopy, we find the 180° meridian needs —4.00 for emmetropia and that by the ophthalmometer we find that —3.00 is needed or to put it another way the ophthalmometer correction is —3.00 x 180°.

In the plane of lens the 180° = —4.00 Fl = 1,000/4 = 250 mm.

Effective focal length when referred back to cornea F2 = Fl + 15 = 250 + 15 = 265 mm.

Power in corneal plane in 180° D2 = 1,000/265 = —3.76 d.
Ophthalmometer reading —3.00 x 180°.
Power in plane of cornea in 90° = —3.76 —3.00 = —6.76.
Far point for 90° from cornea = 1,000/6.76 = 148 mm.
Far point for 90° from lens = 148 —15 = 133 mm.
Highest power in plane of lens 1,000/133 = —7.51.

Resultant cylinder or difference in power in two principal meridians = —7.51 + 4.00 = —3.51 x 180°.

Final R —4.00 ⌒ —3.51 x 180° or —7.50 ⌒ +3.50 x 90°.

This R reads in the corneal plane —3.76 ⌒ —3.00 x 180° or —6.76 ⌒ +3.00 x 90° and can be read on the ophthalmometer either in plus or minus values.

Javal's rule would give us in this case —4.00 ⌒ —3.75 x 180°.

In a case of myopia or myopic astigmatism, we are not very far from the results of the Javal rule. But if the calculations are made for a case of hyperopic astigmatism, using the same figures the result becomes:

+4.00 ⌒ —2.75 x 180° or +1.25 ⌒ +2.75 x 90°

Whereas Javal's rule would give us the same 3.75 either plus or minus, with the rule, which is obviously incorrect.

Neumueller's conclusions as to the accuracy of the Javal rule must be right, and that is: That the Javal rule is incorrect.

Oblique Axis

4. Some one may now remark: "Well, at least, the axis finding is an accurate result of the ophthalmometer. This is true to a certain extent, but only if the meridian of error is at 90° or 180°, and providing there is no marked muscular imbalance.

The same author, Neumueller, in another paper in the October, 1933, issue of the American Journal of Optometry, explains why oblique cylinder findings differ not only in amount, but in position of the axis, from those of the ophthalmometer. Among other reasons he gives which we will cover later, he claims as the predominant cause the following:

Referring back to Javal's rule, "if the corneal astigmatism is at 135° or 45° or nearby, no allowance is to be made for physiologic astigmatism." Neumueller asks: "Does the fact that the ophthalmometer shows axis 135° or 45° wipe out physiologic astigmatism so that it has no influence on the correcting cylinder? His answer is "no." He cites this case: Ophthalmometer —.50 x 135°. Age 50. By Javal rule no deduction is to be made. Neumueller contends that we now have two cross cylinders enclosing 45° in their primary meridian.

The corneal astigmatism at 135° is —.50; physiologic ast. = —.50 x 90°. —.50 x 90 ⌒ —.50 x 135° = —.71 x 112°.

Of course we assume that —.50 x 90 is the correct physiologic allowance. Tables are given for all forms, powers and angle of astigmatism in this article. When expressed in minus quantities, the maximum power is at 90°, the minimum at 180°.

For instance in a patient 60 years of age:

Ophthalmometer reading —2.50 x 90° Phy. All. —.75 x 90° = —3.25 x 90°.

Ophthalmometer reading —2.50 x 180° Phy. All. —.75 x 90° = —1.75 x 180°.

Ophthalmometer reading —2.50 x 145° Phy All. —.75 x 90° = —2.60 x 153°.

In the first case a change of 75 x 90°, in the last a change of only .10 of a diopter, but a change of nearly 10° in axis.

Neumueller's conclusion in his two articles is that: Hyperopic spherical findings combined with minus ophthalmometer findings decreases the resultant minus cylinder, whereas a myopic spherical finding combined with a minus ophthalmometer cylinder increases the resultant minus cylinder.

When the ophthalmometer finding is with the rule, the acceptable cylinder is decreased by physiologic astigmatism. When it is against the rule it is increased.

When the ophthalmometer finding is at oblique axis, the new axis will be between the ophthalmometer axis and the physiologic allowance axis 90°.

The smaller the corneal astigmatism is in relation to the physiologic the more will this deviation be apparent.

5. The axis of the wearable correction is liable to differ from that of the ophthalmometer because of torsions and declinations. We shall go over this point more fully later on.

Post-Corneal Astigmatism

6. We have mentioned under the head of physiologic astigmatism that one theory for the prevalence of against the rule astigmatism is the relaxation of the lid tissues, allowing the astigmatism of the posterior surface of the cornea to predominate.

This would infer that the posterior surface of the cornea is the seat of considerable astigmatism in order to make the physiologic astigmatism from .70 with the rule to against the rule.

Gullstrand and others have measured the posterior surface of the cornea, but I don't know if any effort has been made to measure it in more than one meridian. Such measurement should be easy with modern instrumentation. The values should be lower due to the smaller change of index of refraction the incident light goes through in entering the aqueous from the cornea.

Size and Shape of Retinal Image

7. The size and shape of the retinal image may necessitate a change in the ophthalmometer cylinder before it becomes wearable. This problem can only be solved by objective means. We shall also refer to this later.

The inescapable conclusion in reviewing this subject is that the practical usefulness of the ophthalmometer is greatly overrated. It can be used as an adjunct to other tests, and if so, it has no place in a routine refraction. Whereas, retinoscopy gives us the astigmatic finding closest to the

wearable correction, without excessively complicated deductions. The axis of the correcting cylinder can be found more accurately than with the ophthalmometer, if the operator is skillful, especially when the streak type of retinoscope is used. Axis finding then becomes particularly easy.

Retinoscopy is done mono or binocularly. In binocular fixation many eyes are positioned differently than in monocular fixation, therefore monocular findings may require some modification not only of power due to the play of accommodation, but also of axis due to torsion.

Binocularly we should think that no modification should be necessary, however, with the bright light of the instrument shining in the patient's non-fixing eye, correct binocular fixation is difficult and unreliable, it may be accurate enough to bring in a certain amount of accommodation, but no more.

In vision, that is normal vision, we have two distinct factors:

1. The image formed on each eye by the object (the ocular image).

2. The blending of these two ocular images into a third mental image.

The ocular image is dependent on the refractive status of the eye involved, independent of the other eye, on the transparency of its media and on the sensitivity of its retinal elements.

The mental image is dependent on the two ocular images, at least when both eyes have some vision, and on the brain's interpretation of these two images.

Corresponding Points

To maintain binocular single vision, it is necessary for the images of each eye to fall on corresponding points.

Corresponding points are not necessarily points on the retina equidistant from their respective maculas; they are better expressed as those points which if projected into space will be situated at equal distances from the point of fixation and will answer to proportional degrees of rotation of the eyes for fixation.

Object-points falling on non-corresponding points will be seen double. They cannot appear single without some compensating movement of the eyes. A study of the law of corresponding points, Listings' Law, Law of torsion and an understanding of the horoptor are extremely useful for a clear understanding of ocular orientation.

In refraction we have almost religiously adhered to the writings of Savage and Stevens on myology of the eyes; for some unknown reason the oblique muscles have been entirely ignored, whereas these two authors stressed the importance of the obliques. In fact, they devoted more space to them than to any lateral muscle, as the cause of asthenopia, metamorphosia, etc.

The oblique muscles have their phorias and ductions the same as all peri-orbital muscles and suffer from the same disfunctions. What's more their disfunction causes annoying imbalances to the other muscles. This

is particularly true in astigmatic cases. In addition, while in some cases the recti have a position of rest, particularly with proper correction, the obliques in certain cases of astigmatism have no position of rest, and astigmatic corrections determined in the usual way may aggravate the complaint instead of relieving it.

Oblique Muscles

The oblique muscles are two in number in each eye: The superior and the inferior obliques.

The superior oblique originates from the posterior wall of the orbit, passes through a pulley or trochlea attached to the nasal side and from there to its attachment back of the cornea forms an angle of 45° with the corneal plane.

The inferior oblique, alone of all muscles of the eye, originates not in the posterior part of the orbit, but from a depression in the orbital wall of the superior maxillary bone at the inferior nasal part of the orbital cavity. It courses backward and outward toward the ear and is attached in the posterior, upper outer quadrant of the globe. Its plane of direction forms an angle of 15 to 30° with the corneal plane.

The superior oblique is innervated by the fourth or trochlear nerve. The inferior oblique is innervated by the inferior branch of the third or oculo-motor nerve.

All rotations of the eye occur about its center of rotation.

We shall pass up the various laws governing orientation of the eyes for simplicity. We shall virtually ignore, except when absolutely necessary, the various associated muscles involved when the eye changes from the primary to any secondary position for the same reason. The superior and inferior oblique muscles are not exactly antagonistic to each other and they do not usually function alone. But we may say for simplicity that their combined axis of rotation lies 40° back of the saggital meridian and more or less parallel to the facial plane.

Fig. I is a diagramatic illustration of the obliques and vertical recti in relation to the globe. The attachment of the right eye is purposely exaggerated.

The superior oblique tilts the top of the vertical meridian inward toward the nose and along a saggital axis. The inferior oblique tilts the top of the vertical axis outward or away from the nose, also in a saggital axis. But their action also produces an outward and downward deviation and an outward and upward deviation respectively.

The lateral recti have no effect on torsion, but the vertical recti have some action. Due to its attachment at the apex of the orbit, which is back of the eye and on the nasal side of the center line of the eye, the superior rectus tilts the eye up and in and tilts the top of the vertical meridian inward, the inferior rectus for the same reason tilts the eye down and in and rotates the top of the vertical meridians outward.

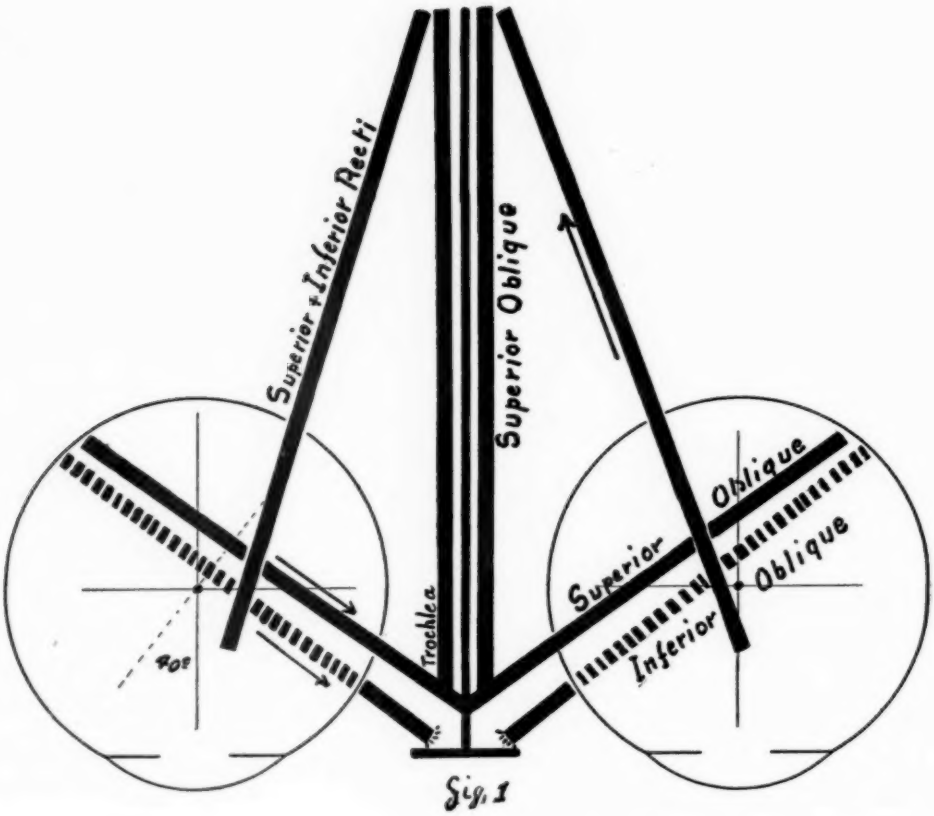

Fig. 1

This rotating movement is only true when the eyes are pointing no further out than 30° from the primary position. At that point their action is only up and down.

This rotating motion of the eyeball is called torsion either as produced by the vertical recti or the obliques, or both in combination.

We thus see from the diagram that movements of the eyes bring in play a number of muscles. The only exception would be in lateral versions, if the attachments of the recti muscles did not vary from the ideal, the only muscles involved would be the lateral recti.

Stevens analyzes these movements as follows:

Direction	Muscles involved
To nasal side	Internal rectus
To temporal side	External rectus
Upward	Superior rectus and inferior oblique
Downward	Inferior rectus and superior oblique
Upward and to nasal side	Superior rectus, internal rectus and superior oblique
Upward and to temporal side	Superior rectus, external rectus and inferior oblique
Downward and to nasal side	Inferior rectus internal rectus and superior oblique
Donward and to temporal side	Inferior rectus, external rectus and superior oblique

On the diagram, the vertical recti of each eye are seen as one line and the lateral recti are omitted for simplicity.

The primary position may be expressed as that position the eyes are in when with the head erect they are fixed for infinity, turning neither to the right or left or up or down.

Torsions

Torsions may also be called rotating ductions. They may be conjugate as in versions, under proper stimulus or and most often their action is synergistic as in convergence. They perform the same function as convergence, that is, to bring corresponding points of the retina, in line with the ocular image of objects into space.

That they tort can be demonstrated in an ordinary stereoscope. If the top of the vertical meridians of stereoscopic pictures are rotated outward from each other, for some time the mental image will be seen singly, but leaning away at the top. This torsion is voluntary and made to compensate for the fact that corresponding points on the stereoscope fall on non-corresponding points of the retina. Torsions are said to be positive when the upper part of the vertical meridians are turning outward from each other and negative when they turn inward from each other.

The limits of voluntary torsion seems to be about 11° for each eye in the positive direction or a total of 22° if both images are rotated at once. If one image alone is rotated the limit is about 12 or 14°. In a negative direction, torsions are slightly less. If the upper part of the vertical meridians are tilted inward toward each other, the images may be kept single through a rotation of about 9 or 10° each or a total of 18 to 20°.

If two vertical lines are seen through an instrument such as the clinoscope and positive torsion induced by rotating the tubes away from each other at the top, the combined image seen will appear to lean outward at the top and approach the horizontal position as an arrow shot upward and away from the observer.

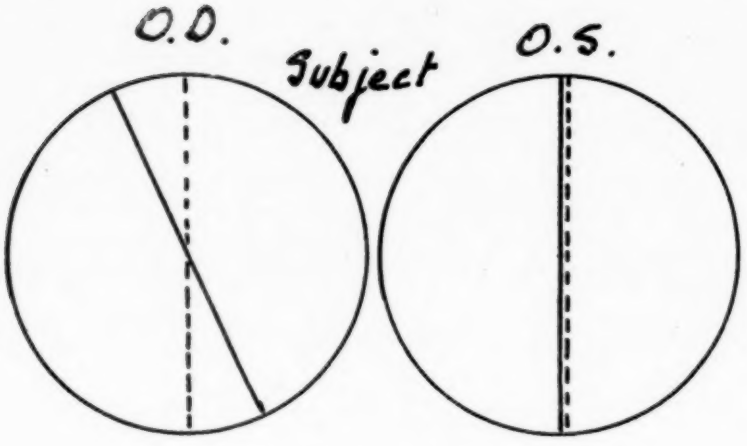

Fig. 2.

If the rotation is negative or inward at the top of the tubes the image will appear to lean out at the bottom as an arrow shot away and downward from the observer.

Declinations

If two vertical lines are sighted through two tubes placed against the eyes in the primary position, in many cases one of the lines will be seen to deviate from the vertical.

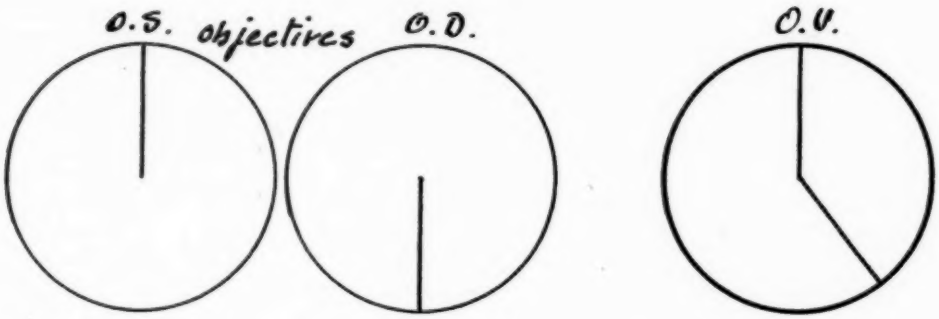

Fig. 3

Helmholtz and others observed the same phenomenon and concluded that this deviation was physiologic and present in all eyes to the extent of about 1 ¼°. However, better methods of investigation later revealed to

Stevens that this tilting or declination was not uniform, nor present in all eyes, that many eyes showed no declination and that some showed high degrees of declinations without apparent complaint. Stevens concluded that these were anatomical peculiarities proper to the individual cases, due to the variations in the attachment of the muscles.

The word declination is here used following the terminology of Stevens, instead of the word cyclophoria, the latter word suggesting various misconceptions in the mind of the hearers. If in looking through two tubes, the top of the right eye image tilts to the right at the top, the declination is negative, if the right eye image tilts to the left at the top, such as is shown in Fig. 3, the declination is positive. This apparent discrepancy in plus and minus position is explained by the fact that the tilting of the right image to the right at the top corresponds to a tilting to the left of the vertical meridians of the eye.

The mental interpretation is opposite to the rotation. The brain is not conscious of the malposition of the vertical meridian of the tilting eye, it assumes that the vertical meridian is truly vertical while it is not. So those parts of the image lying on the right side of the vertical meridian are projected back into space to the left of that imaginary vertical meridian.

Just how much declination is physiologic has not been definitely ascertained, that some is anatomically normal or can be supported without inconvenience is unquestionable, but it is equally true that declinations assume a pathologic aspect.

Stevens goes even further and ascribes all sorts of ills to them with much apparent justification.

Stevens states that various peculiarities of facial expression are caused by declinations. He offers an empirical scheme to explain the relations between declinations and heterophorias. This scheme, most interesting, is too lengthy to be incorporated in this paper.

If strong prisms are placed base in or out before the eyes, the tilting of the vertical meridians show that the oblique muscles assume their position of rest and the deviation, if any, becomes manifest providing diplopia is produced by the prism.

The etiology of squint is linked with declinations and there is little doubt that many an obstinate case of squint could be successfully completed if attention were paid to declinations.

In these cases the declinations are either pathologic, or are compensating declinations to correct an astigmatism, and they stimulate the innervation of the third or the sixth nerve thus causing the squint. The vertical recti may be involved, but the obliques more than likely are the primary cause of the deviation.

Unfortunately, the Stevens clinoscope has disappeared from the market and an accurate instrument of this type is necessary for the

determination and study of declinations. The same instrument can be used for the measurement of torting power or torsion.

No useful work can be done in declinations or torsion with the most modern phoropter. The use of two Maddox rods is unsatisfactory because the fuzziness of the light streak makes accurate matching impossible. The angular measurements are a little crude, and the external field is not completely excluded. We should remember in considering declinations, or as some call them cyclo-phorias, that they can be both synergistic and conjugate. They are also apt to be the cause of heterophorias and asthenopia.

Declinations can be overcome by surgery or orthoptic treatments just as other forms of heterophorias.

Now as to the effect of astigmatism on torsion or vice versa. We shall continue to consider declinations in the primary position only not to unduly complicate the subject.

Stevens claims that astigmatism is caused by loss of sphericity of the eyeball and that in some cases this loss of sphericity is due to the traction exerted by the muscles surrounding the eyes. So much so that he claimed he reserved correction of the astigmatism until the declinations if any were eliminated, the astigmatism often disappearing.

The statement may seem debatable, but we can't criticize knowingly as we have not tried to put his theory into application.

Savage has carried on further research in this subject and has come nearer to a practical application of the knowledge of declinations.

Distortion

A spherical lens may be described as a lens having the same prismatic power in all meridians and also that a cylindrical lens has unequal prismatic power in all its meridians.

Let us take a plus +2.00 cyl. x 180°. The power of that cylinder is zero at 180°, gradually increases until at 90° it reaches its maximum refractive power: +2.00. At axis 45°, the refractive power is half of its total power or +1.00. Now the prismatic power or displacement power is proportional to the refractive power, therefore the image of an object seen through a cylinder is slightly displaced toward the meridian of greatest curvature, or base. The meridian of greatest curvature is the highest power in a plus cylinder and the axis in a minus cylinder.

This has been demonstrated by Savage by taking photographs of a rectangle through a camera. This produces a clear and symmetrical picture. Then a cylinder of +3.00 diopters combined with a +1.50 sphere to secure the needed focal interval was placed in front of a camera at axis 135 and another picture taken without moving the camera. The result was a very pronounced leaning of all meridians producing a non-rectangular parallelogram. Now note that the rectangle was not turned about its

center, but distorted toward the meridian of greatest curvature, in this case axis 45°.

In an eye astigmatic three diopters, the same condition must exist, and similar points of the images must fall on dissimilar points of the retina. Diplopia would be the natural result, if it were not for the oblique muscles.

Vertical astigmatism or horizontal astigmatism will not cause such a displacement of the retinal image, only oblique astigmatism; and as the law of corresponding points must be obeyed some compensatory movements of the eye are needed to remedy the disparity.

The only exception is in oblique astigmatism in both eyes with the axii parallel. In that case while there is distortion, it is equal in both eyes and in the same direction. So all object points fall on corresponding points of the retina and appear as single.

This distortion as evidenced by the camera is compensated equally in the two eyes, even if only one is astigmatic, by rotating the vertical meridians counter to each other—that is, both in or both out at the top. Thus the strain is divided between the two eyes. 10° of tilting will be compensated by 5° rotation of each eye in the proper direction.

This action of the obliques is not temporary as in ductions, but permanent at least for the duration of the uncorrected astigmatism and in that way is more like a tropia.

Savage, in fact, calls this compensating cyclotropia.

Being more or less fixed, it stands to reason that any change in the visual system such as the application of a cylinder, is going to cause a change from that apparent state of rest to a new dynamic position. It is possible that in time the eyes will acquire a new position of rest, but not immediately.

It is demonstrable that natural astigmatism with the meridians of greatest curvature diverging above will cause a rotation of the vertical meridians inward at the top, toward the nose, by the obliques, to satisfy the unavoidable law of corresponding points and maintain binocular vision. Conversely, when the meridians of greatest curvature converge above the inferior oblique will be brought into play for the same reason.

Savage ventures the idea that if such a rotation is impossible or impractical for comfort, that amblyopia ex-anopsia may be the result, and that this outcome is more common than ordinarily supposed.

Oblique Insufficiency

The oblique muscles may be insufficient, particularly the superior obliques, and in the case of insufficiency of the superior obliques, astigmatism with the meridians of greatest curvature diverging above would make any compensatory movement very difficult, if not impossible. In such a case, astigmatism axis 90° or 180° would be worse than astigma-

tism at 135° and 45° (greatest curvature at 45° and 135°) for right and left eye respectively as parallelism of the visual axii would have to be maintained at the expense of strain of the superior obliques, whereas in the oblique astigmatism requiring a plus declination, by action of the comparatively stronger inferior oblique, the ideal condition would be approached.

An insufficiency is thus a declination phoria, or as Savage calls it a cyclo-phoria. It may prevent one from finding the true axis of astigmatism by any means whatever, until the true extent of this phoria is determined.

Taking a pair of eyes whose meridians of greatest power diverge above as: OD. +3.00 x 135, OS. + 3.00 x 45.

The meridian of greatest curvature of the eye is at 135° in the right and 45° in the left. It would be opposite if the case were one of myopic astigmatism, as the axis of the correcting cylinder in that case coincides with the meridian of least curvature. We ignore the spherical element.

These eyes uncorrected when viewing a rectangular parallelogram produce a combined mental image of a trapezoid with the longer side above.

The diplopia will be corrected if the eyes are able to, by rotating the vertical meridians inward and nasalward, so that the two images blend together in the form of this trapezoid, the distortion will remain for some time and eventually disappear, but the declination of the obliques will remain and become a lifetime habit.

When this declination is remedied by correction of the astigmatism in the proper manner, the declinations do not immediately disappear but continue with the correction on, thus causing a distortion opposite to the one present originally in the uncorrected eye. With the correcting cylinder on, the rectagular parallelogram becomes a trapezoid with the long side or base below.

In time, possibly a long time, the eyes learn not to tort unnecessarily and the distortion will disappear, only to reappear if the glasses are removed.

Heretofore the method used in eliminating this distortion due to the correcting cylinder, was to determine the full error either by dynamic skiametry or under a cyclopegic and give one-third of the full correction to begin with. The axii were placed where the eyes have their vertical meridians parallel with the median plane of the head. Then later the correction was increased in a number of changes to its full strength, thus gradually getting the brain to eliminate the distortion.

The inconvenience of this plan is that many changes are required before the full correction is accepted, entailing considerable expense.

Steele Rule

Another way is to give the full strength of the cylinder and place the axis in the dynamic position of the eyes, that is with declinations and the obliques working as was habitual; then the lenses are gradually rotated so as to relieve that particular oblique and place the load on the other, until the cylinder axis corresponded to that of the error without declination.

This is Steele's method and the rule for its application as given by Savage is:

"When the axii of plus cylinders are within 45° from the vertical and converge toward each other, rotate the axii toward the greatest convergence permitted by visual acuity, and when they diverge above, set them at the greatest divergence permitted by visual acuity."

This is applicable only for axii laying 45° from the vertical. When the axii are more than 45° from the vertical the shifting should be in the other direction.

In other words: When the axii are less than 45° from the vertical, with plus cylinders, turn them away from the vertical to reduce the distortion.

When they are more than 45° from the vertical, turn them toward the vertical.

Minus cylinder should be shifted opposite to plus cylinders. The shifting should be enough to neutralize the distortion and every few days they should be shifted back toward the position shown in monocular test, this position presumably being the position of rest.

Insufficiency of the inferior obliques is comparatively rare, therefore astigmats with the meridians of greatest curvature diverging above become accustomed more quickly to the correction than those with meridians of greatest curvature converging above. The reason is that when the meridians diverge above, the load has been on the superior obliques and those more willingly give up the load than the inferior obliques.

The distortion of astigmatism and of its correcting cylinder, as well as declinations and torsions should be studied for the following reasons:

1. That the operator may know where to place the cylinder in oblique astigmatism, to reduce the distortion as much as possible and at the same time reduce the strain on the oblique.

2. That he may predict to the patient, the distortion and its form, also possibly its duration, so that he may inspire confidence to the patient in his procedure.

3. That he may achieve greater success in the correction of amblyopia ex-anopsia by more intelligent use of the cylinders.

4. That he may obtain greater success in the correction of heterophorias and heterotropias by intelligent use of cylinders.

5. That he may correct defects of posture, particularly in children, due to conjugate declinations.

6. That he may increase his prestige by getting a better batting average in the fitting of bifocals in difficult cases.

We cannot go into every detail of this subject. The subject is rather intricate, especially when you consider positions other than the primary position, for instance, with the eyes depressed as in reading.

Much work can yet be done in this subject, and we may look forward to interesting applications of the various phenomenons of torsions and declinations in future refractive work. If a measurement of convergence and ductions is useful in refractive technic, why should torsions not be equally useful? The obliques are just as much involved in ocular orientation as the lateral or vertical muscles.

I hope that this more or less superficial outline has aroused interest in some of us, for this neglected subject.

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THE VALUE OF DENTAL EXAMINATION IN OCULAR DISORDERS*

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Rarely is the dental surgeon aware of the extremely valuable services he can render his patient as a diagnostician and consultant. As the conscientious physician will give his patient a thorough examination, no matter what the complaint, so must the dentist look upon the mouth and related tissues as his field which must be examined, and then go even further and communicate with the patient's physician if there is the slightest indication for it.

Routine examination of our field as related to operative and prosthetic dental service is not sufficient. The mouth and its surrounding tissues play a role equally as important as the teeth and their investing structures.

This paper is written in an endeavor to stimulate closer co-operation between the patient, the dentist and the optometrist.

The importance of localized, often symptomless foci as sources of infection in various eye diseases has become apparent through the work of Billings, (1, 2, 3), Rosenow, (23, 25, 27), Nickel, (26), Meiser, (23), Irons and Brown, (15, 16), and Haden (14), as well as a host of other workers in the field of focal infection.

Billings (1) defines focal infection as a metastatic, systemic or local condition due to infections, micro-organisms or their toxins carried in the blood or lymph stream from a focus or foci of infection. A focus of infection is a localized or circumscribed area of tissue containing pathogenic micro-organisms and may be either primary or secondary. A primary focus is a principal or first infected tissue area, a secondary focus or foci is a circumscribed tissue area invaded by pathogenic micro-organisms carried in the blood or lymph stream from the primary foci.

Local tissue infection, partly or wholly confined may exist in any part of the body. A primary focus of infection is usually found to be located in tissues communicating with cutaneous or mucous surfaces. The rectum, the male genito-urinary tract, especially the prostate, and deep

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urethra, may all act as a foci of infection but the most common site for primary foci of infection is in the mouth, ear, pharynx and nasal sinuses.

Primary foci of infection in the mouth are usually confined to teeth. Dental infections occur in a large proportion of all persons, this fact may be made more clear when it is pointed out that approximately 25% of all patients registering at the Mayo Clinic are referred to the Section in Dental Surgery in order to rule out or confirm suspected foci.

Because of this prevalence of dental infection, care must be exercised in ascribing to such infections a casual role, when they happen to be found in patients with diseases of the eye traceable to foci.

The exact mode of transmission of infection from the dental focus to the eye is still a question. Any part of the eye may become infected, but the iris, the ciliary body and the choroid are the most frequently involved.

De Schweinitz (10) in recognizing the significance of dental disorders stated: "Speaking purely as an ophthalmologist, I desire to say this, and I know my ophthalmic confreres will agree with me, namely, that the proper management of cases of uveal tract disorders, in particular of some forms of keratitis and of certain disorders of the retina and of the optic nerves, demands the co-operation of the physician, the urologist, the ophthalmologist, the otolatyngoloist and the dental surgeon."

Lang (18) in 1913 was one of the first to publish observations on the influence of dental sepsis on diseases of the eye.

Eyes previously healthy may become diseased by the transmission of organisms of infected teeth in one or more of three ways:

1. Direct extension through bone. Infected teeth in the maxilla lead to the production of an infected process which destroys by direct extension the bone of the upper jaw and through this destroyed area may directly affect the orbital walls finally producing an orbital cellulitis or retrobulbal neuritis. Benedict (4) claims that such extensions of infected processes about maxillary teeth seldom affect the interior of the eye but are found as abscesses of the lids particularly the lower, abscesses of the sinuses, emboli and abscesses of the frontal lobe with atrophy of the optic nerves and periostitis.

2. By direct extension. The micro-organisms may pass by direct extension along the periosteum of the malar bone and give rise to the same previously mentioned eye disorders.

3. Transfers of micro-organisms from the focus of infection about the infected teeth to the eye by means of either the blood or the lymph circulation.

This last method of transfer is believed to be by all means the most frequent and consequently is the most important.

Rosenow (25) has shown that organisms taken from infected teeth are capable of producing diseases of the eye when injected directly into the blood stream of animals, and furthermore that such organisms have a

selected affinity for certain structures of the eye and that within certain limitations this selective affinity of the micro-organism is characteristic of the strain and is maintained through several cultural transplants of the organism.

Although optic neuritis, scleritis, keratitis and conjunctivitis have been reported as having been believed to be caused by infected maxillary teeth, the iris and the choroid are the two most common portions of the eye attacked by micro-organisms originating in periapical dental involvement.

Benedict (4) and others are of the opinion that in eye diseases when investigation of the dental condition is warranted that an equally important field or source of the eye disorder is the reflex irritation from crowded unerupted or impacted teeth. Many instances can be gathered from the literature of reflex spasms of the lids or extraocular asthenopia, amblyopia, stabismus, hyperopia and even so-called tropic disturbances, believed to be due to irritation from the teeth through reflex distribution of the fifth cranial nerve.

Benedict (4) cited a case in which the patient, a woman aged 22 complained of periodic twitching and pulling of the right eyelid for the past three and one-half years. There was no photophobia at any time but a dull moderate headache of the migrain type on the right side of the head and face accompanied the twitchings and contraction of the lids of the right eye which had persisted at all times, giving the appearance of ptosis. A dental examination was made and a right impacted molar as well as three other impacted molars were extracted. Nine months later the patient wrote "since I had my impacted teeth removed my eyelid has pulled but little."

The observations of Lavy, Steinbugle and Pease (20) in some 57 patients with definite dental sepsis suffering from various eye conditions were that with one exception all of the eight patients cured and 21 patients materially benefited presented dental sepsis on the same side as the affected eye.

Marinasse (22) reports that French ophthalmologists do not pay any attention to the teeth as etiological factors in ocular lesions. He is of the opinion that from a standpoint of foci of infection that an infected periapical area with a chronic fistula is not nearly so apt to be responsible for the production of ocular lesions as one which has no external communication. Marinasse in his series of cases found that dental causative factor and the ocular lesion were on the same side, the infectious dental process always in the vicinity of the maxillary sinus and the teeth most usually affected are the upper bicuspids.

Until 1919 when Lewis (19) published his report demonstrating the selective affinity for the iris of strepococcus viridans from periapical infection secured from a patient suffering from iritis, there was little direct evidence to prove that organisms may assume an affinity for the iris without being sensitized by passage through the eyes.

In 1921 Gardiner and Meisser (12) reported the experimental production of iritis in rabbits through two animal passages, with a streptococcus isolated from an infected tooth in a case of acute iritis.

Haden (14) in 1923 in a long series of experiments in cases of acute iritis, episcleritis, uveitis, and hyalitis has had similar results. He reported finding lesions of the eye in 68% of 66 rabbits injected with freshly isolated cultures from teeth of patients suffering from metastatic infections of the eye. In a control group in which parallel injections were made of cultures from infected teeth in patients were well or were suffering from some other condition lesions of the eye developed in only 14.89% of 169 rabbits injected.

Rosenow and Nickel (27) in a more recent attempt to determine, by means of experiments the relative importance of local infections in the teeth, tonsils, prostate gland and uterine cervix in patients who had eye lesions concluded that—striking evidence of specificity of the streptococcus isolated from each of the foci was obtained while evidence of this specificity was not obtained in the control group. Two hundred and fifteen rabbits were injected intravenously from 74 cultures of streptococci derived from the different regions of 69 patients who had intraocular lesions, iritis or other lesions of the uveal tract developed in 48%. The incidence of ocular localization in that portion of the 215 animals that received injections of cultures from teeth was 53%, from tonsils 67%, prostate 40%, and uterine cervix 50%.

Rosenow (28) and his associates at the Mayo Clinic in their experimental work with the cataphoretic time and velocity of streptococci isolated from atria of infection in patients suffering from systemic disease, using definite culture methods and growth media as suggested by Rosenow (30) have shown (29) that streptococci isolated from dental infections in patients suffering from ocular disorders all fall into a similar cataphoretis potential group with a velocity ranging from 2 to 3 seconds and furthermore intravenous injection into animals will, in the great majority of cases, reproduce in the animal the identical ocular lesions of the patients. Rosenow and his associates have therefore added another link in the chain of dental foci of infection as an etiologic factor in the production of ocular lesions.

Many writers believe that infection from suppurations beginning at the gingival margin may be a common source of eye inflammations.

Stafne and Cook (31) in a bacteriological study of pyorrhea alveolaris were able to show that the same type of streptococci may be secured from deep pyorrhea pockets and infected investing tissues of the mouth of patients suffering from ocular disorders as from periapical areas of infected teeth of patients with similar eye affections.

Cook (7) in a separate study injected intravenously a series of 40 rabbits with cultural material obtained from pyorrhea pockets of ten patients suffering from iritis and successfully reproduced corresponding lesions of the eye resembling those of iritis in 45% of the animals.

In a series of eight cases of iritis in patients from which cultures were secured from the apical areas of infected teeth, using the cultural method as described by Rosenow and injected intravenously into 32 rabbits, Cook (8) was successful in reproducing eye lesions simulating those of the patient in 63% of the 32 animals injected.

Finnoff (11) agrees with Cook and is of the opinion that pyorrhea is more of an infectious etiological factor in the production of ocular disorders than periapical infection.

Keilty (17) concludes in his extensive work on bacterial findings associated with peridontoclasia that "the Gingivae, the seat of gingivitis, offer the largest and most important single portal of entry for micro-organisms and as such are the most potential sources of foci of infection in the mouth.

Irons and Brown (15) in a summary of etiology of one hundred successive cases of patients suffering from iritis found dental periapical infection to be the sole etiological factor in seven cases and a contributing infectious etiological factor in eleven others.

In a second series of 100 successive cases (16) of iritis published some eight years after the first (15), Irons and Brown described nine cases as apparently due to dental infection of the periapical type. Five of these cases were unassociated with other infections, in each of the four others tonsillar and sinus infections were found. Dental infections associated with other types of infections such as syphilis, gonococcal infections, infected tonsils, genito-urinary, and sinus infections were found in 43 other patients.

Some three years later Irons and Brown (16A) reported a follow-up on 50 cases covering from three to 12 years. Forty-five patients had had no recurrence with unfavorable results, but of those patients showing favourable results 37% had had their tonsils removed and 30% had had their infected teeth extracted, thus 67% were benefited by the elimination of oral infection.

Greenwood (13) in a discussion of Irons and Brown's later paper stated: "I think most of us will agree that in private practice the question of focal infection in the teeth is of more importance than that in the tonsils, for there are more cases which can be demonstrated to be due to focal infections and find the streptococcus that Dr. Rosenow has proved to be the one that has a particular affinity for the iris."

Cruttenden (9) in a series of 55 cases of patients suffering from iritis, uveitis, and choroiditis found that 82% of the entire series had dental infection in some form either alone or combined with some other infection. Some form of nose and throat infection, but chiefly tonsillar infection was present in 53% of all cases. In Cruttenden's series 77% of follow-up cases showed improvement after the foci were eliminated.

Lowell (21) feels that in ocular disorders attributable to foci of infection that the teeth are the first tissues to be examined and emphasizes

the special care which must be exercised in taking roentgenograms of suspected teeth. It may be necessary to take them at several angles to insure a correct diagnosis.

Benedict advised the removal of all dental foci in the treatment of ocular disorders and expressed the belief that there should be a satisfactory system of prophylaxis.

Black (6) believes that fully 50% of all adults have oral infection either periapical alveolar abscesses or chronic suppurations beginning at the gingival margin, and therefore feels that it is the duty of every optometrist and ophthalmologist to at least consult the dentist in ocular lesions in which foci of infection may be either the sole or contributing factor in etiology.

Keevil and Wilkins (32) are of the opinion that in many cases of serious inflammation of the eye, infected teeth may be associated with other foci of infection, such as the sinuses and the tonsils. In such cases it is impossible to say how much teeth have contributed to the cause of eye lesions, but their evil influence should be removed.

It has been my good fortune while a fellow in the Section on Dental Surgery at the Mayo Clinic, to have been associated with Dr. Rosenow and his co-workers, and to have witnessed the special affinity and selective localizing power that streptococci secured from the teeth of patients suffering from ocular lesions have for the ocular structures of animals.

Conclusions

1. Co-operation between the physician, the urologist, the ophthalmologist, optometrist, the otolarngologist and the dental surgeon is the keynote of success in the treatment of ocular disorders for it is only thus that the relief of human suffering and the prolongation of human life shall achieve what must be our professional aim—the help of those who seek our advice.

In order to render this service to the patient, each must conduct a careful examination in their respective fields. The dentist in order to render a satisfactory, accurate report of the cases entrusted to him must utilize all the agencies possible, the roentgen ray, pulp vitality tests, transillumination and a carefully taken dental and oral history combined with a scrutinizing clinical examination are all necessary before the dentist can justifiably draw his conclusions and present to his fellow co-workers a satisfactory, accurate report of the dental findings of the patient.

2. Many workers have demonstrated the special selective affinity of streptococci secured from the apical regions of infected teeth of patients suffering from ocular disorders. These facts should be regarded as both clinical and experimental proof that dental periapical infection may be a definite etiological factor in the production of ocular disorders from which the patient may be suffering.

3. Elective localization of this streptococcus or its toxins has been obtained in a sufficiently high percentage of animals in a large enough series of cases, by methods sufficiently variable, and with conditions sufficiently like those at hand in patients, to be of most important significance.

4. Pulpless or devitalized teeth which are apparently negative roentgenologically may bear as important an etiological relation to ocular disorders as those which show positive roentgenological periapical involvement.

5. Streptococci isolated from pyorrhea pockets and investing tissues must be considered potential sources of foci of infection in ocular disorders.

6. Autogenous vaccines have been used to supplement the regular course of treatment with highly gratifying results.

7. The iris, the ciliary body and the choroid are the most frequent eye structures involved by dental infective processes.

8. Special emphasis should be placed in the taking and reading of roentgen rays of suspected teeth.

9. Removal of dental foci or infection, whether it be located in the peridontium or in the periapical region, for ocular lesions while not universally successful, has nevertheless a percentage of successes high enough to indicate that the eye specialist has been greatly aided in the treatment of patients by the intelligent co-operation of the dentist.

10. The value of a complete and thorough Roentgenological and clinical dental examination cannot be stressed too strongly in the cases of patients suffering from ocular disorders.

11. Even when a definite general toxemia exists, as in the case of syphilis and tuberculosis, sepsis of the mouth should be treated because the general toxemia seems to sensitize eye tissues to infection existing in even distant foci.

12. The proper care of the teeth is one of the most important factors in the present day public health program and in the scheme for the conservation of vision.

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VISUAL FIELD STUDIES

The writer has said on several occasions,[1, 2, 3] that in his belief perimetric visual field studies should always be prefaced with at least one and, if time permits, two experimental trials to acquaint the patient with the details of the test decided upon, and to enable him to more or less familiarize himself with what is expected of him. In making a color field analysis for instance, we are in reality asking the patient to accomplish a visual task or feat that normal ocular reactions are in fact poorly equipped to do. The same is true even to a greater degree in using the campimeter in making a study of the central section of the visual field.

When the patient looks at a specific object or as he does in these tests, a specific point, he is said to "fix" that point. An imaginary line joining the anterior nodal point of the eye to the point of fixation is

[1] Koch, C. C. Limitations of Stereo-Campimetry. Amer. Jour. of Optom. Vol. 10, No. 6, pp. 226-227. 1933.
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termed the line of sight. The image of the object at the point of fixation is formed on the fovea centralis, but only a minute area of this object is fixed at a time. In fact, however close two points may be, provided that they can be seen as separate points it is impossible to clearly view them both at once. One of them is being looked at, rather than the other.

As is well known the line of sight is not coincident with the optic axis. It is inclined inwards and downwards with respect to it by 5 to 7 degrees. Since it passes through the anterior nodal point it does not pass through the center of the pupil, but through a point about half a millimeter from the center towards the nasal side. This is, of course, in the normal case. In abnormal cases the pupil may be so far off axis that the line which represents the line of sight may enter the globe of the eye near the extreme edge of the pupil.

It is difficult to account for the uniqueness of the line of sight and the curious selectiveness by which we can look at either of two just separable points and not at both simultaneously. Laurance[4] and Guild[5] both believe that it probably arises not from any property of the eye but from the inability of the mind to direct attention to more than one point of the retinal image at a time. Experiments prove that retinal definition falls off very rapidly from the macular area of the retina outwards. Few people realize the very poor general image which the retina really receives. The fact that we only look at one point at any moment prevents us from realizing that the greater portion of the image received by the retina is only a suggestive blur. This is due to the fact that immediately any part of the object viewed attracts our attention we automatically direct the line of sight to it and then immediately fix that particular part. It is only after some training that a patient is able to give some attention to objects other than the one fixed.

This fact renders very difficult the measurements of the properties of the non-foveal retinal regions. Only a subordinate degree of attention can be given to these observations, for the primary portion is inexorably demanded by the object at the point of fixation. The moment one gives less attention to this fixation point than to the marginal object the line of sight is immediately switched over to the latter, which then ceases to be marginal. The divided attention, combined with bad definition, renders such observations among the most difficult for us as optometrists to get with any degree of accuracy, and this fact accounts for the need of making field studies with the perimeter and campimeter on several occasions before the findings can be relied upon with an degree of certainty.

C. C. K.

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OPTOMETRIC EDUCATIONAL STANDARDS IMPROVING

For many years optometric schools, colleges and universities have required of the applicant, standard university credits for all students wishing to enter or enroll in their optometric departments. In other words, the students must have finished an accredited high school, having taken certain specific subjects and having passed in these high school subjects with at least a "C" average. In this our optometric colleges have kept pace with the educational development in other professional fields.

Of late, however, due to a desire on the part of our educators to give the student a more thorough ground work in the fundamentals of ocular refractive science and also to enable him to participate in a more rounded out clinical program, the tendency has been growing among the colleges to require of the applicant not only a satisfactory high school diploma but also two years of pre-optometric collegiate work as well.

With this educational background for its student body the optometric college can then devote its entire time (either two or three years) to the specific problem at hand, i.e., the educational development of the optometrist-to-be in the specific fields relating to ocular science. And this is as it should be. As a satisfactory working example of this plan let us use the Los Angeles School of Optometry, which in June, 1933, took over from the University of Southern California, its able optometric faculty, its excellent optometric equipment and responsibility for the continuance of the program of optometric education inaugurated by the university.

The Los Angeles School of Optometry in re-entering the field of optometric education brings to its task the experience gained in 20 years of most successful operation as a private school, plus five years of intimate association with university methods and ideals. The new program is based upon a continuance of university standards. Two years of an approved pre-optometric curriculum, completed in an accredited university or junior college, constitutes the entrance requirements.

Quite obviously foundation studies in pre-optometry subjects are most efficiently and economically encompassed in a university or junior college which alone can provide adequate and necessary laboratory equipment and whose faculty consists of experts in the various subjects covered. Furthermore such instruction is available in the student's home community, usually without great tuition expense. The plan adopted by the Los Angeles School of Optometry conforms to that in all other professions, and enables the student to complete his professional training in two years away from home with a stronger emphasis on both the pre-optometric and professional optometry studies, especially stressing the three practical aspects of routine optometric practice: the refractive, the orthoptic treating and the economic phase.

Included in the approved pre-optometric program, constituting an ideal background for the subsequent professional training, are such sub-

jects as English, Physical Education, Health Education, a Social Science, Chemistry, Zoology, Psychology, Anatomy, Physiology, Physics, U. S. Constitution, and Speech. With such a foundation much better progress is assured and a more intelligent comprehension of the fundamentals of optometry achieved than were the professional interests "sandwiched in" with the basic preparatory studies.

In keeping with accepted standards the degree offered by the Los Angeles School of Optometry for the four years course (two years pre-optometry and two years professional optometry) is Bachelor of Science in Optometry. This requires satisfactory completion of 124 semester units of collegiate work in approved subjects. A semester unit represents one hour of recitation or three hours of laboratory work per week during the semester. Satisfactory completion implies a "C" average upon all work attempted.

A noteworthy innovation is the inclusion of a fifth year of studies which serves as the basis for the doctorate degree and also makes provision for the carrying on of much needed research. That such an advance constitutes a reliable ideal is proved by the fact that already students are enrolling for it, and others have signified their intention of so doing. This new move eliminates in a large degree the objections raised by this writer[1] several years ago in discussing the matter of professional degrees awarded students in optometric courses. Thus is inaugurated a movement in optometry to make its degrees conform to the standards obtaining in other recognized professions. The results of this move will be watched with sympathetic interest by all who have at heart the well being of the profession of optometry. C. C. K.

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BEDSIDE REFRACTIONS OF ASTIGMATIC CASES

Several years ago, in discussing the important matter of refracting at the bedside, the writer[2] outlined a routine procedure which, when followed, served adequately in most cases. However, in cases of large amounts of astigmatism the procedure in these bedridden cases was at best difficult, and the results were none too good. These cases are of course infrequently met up with, but when they are, the work must be done with portable equipment and with the patient in a semi-reclining position and every help which may be had is needed. With this in mind I cast about for more suitable technics to add to those already in practice.

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After trying various things I found that the subjective technic suggested by Sutcliffe[2] seemed to best solve the problem.

The additional equipment needed was as follows: an astigmatic fan dial and a block or series of parallel lines capable of being rotated to any particular meridian. The procedure is to use the test-letters only to ascertain the visual acuity before and after testing, and to rely upon fitting separately the two principal meridians without further reference to the test-letters. The patient is asked to state which lines in the fan are the clearest. The set or block of parallel lines is then fixed at right angles to the clearest line on the fan dial and therefore at the worst position at which they can be seen. Convex spherical lenses then placed before the patient's eye and if the vision is improved are increased in strength until the best result is obtained; the fan lines are then again resorted to and the patient is asked to again pick out the best set; a suitable concave cylindrical lens is then put in the trial frame and turned until the fan lines appear equal in clearness. Should, however, convex spherical lenses not improve the block lines in the first instance, the procedure is repeated from the start with the block lines at the opposite meridian or axis. If the convex sphericals are still useless, concave sphericals are tried and the same procedure followed. If the block is still seen most clearly without the aid of a lens, it is assumed that that particular patient is a simple astigmat and that a concave cylinder with its axis properly oriented is alone required. The advantage, according to Sutcliffe, of such a system is that the most difficult complicated cases of astigmatism are gradually eliminated at the start and there is little tendency to excite the accommodation. This subjective procedure was found to be of value by the writer in examining bedridden patients in which a high amount of odd-axis astigmatism was present. The tests are simple and easy to carry out in the home and under the average lighting found in the sick room and supplement to a marked degree the skiascopic and previously used subjective technics. C. C. K.

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ERRATUM

In the December, 1934 issue of the AMERICAN JOURNAL OF OPTOMETRY the price of Henry Rich Higley's new book *Strabismus* was erroneously placed at $6.50. (p-477). The correct price of this book is $4.50.

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